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# (54) ATOMIZATION DEVICE

(57) The atomization device comprises a motor (1) rotatably driving a spinning disc (2) by means of a rotating shaft (3), and cooling means for cooling said spinning disc (2), wherein said cooling means comprise a cooling circuit (4) extending around at least one portion of the rotating shaft (3) and below at least one portion of said spinning disc (2).

The invention allows providing an atomization device in which the rotating shaft of the motor is perfectly aligned with the spinning disc, thereby avoiding the use of mechanical transmission elements.

EP 3 753 655 A1

## Description

**[0001]** The present invention relates to a metal powder atomization device, particularly to a centrifugal atomization device in which molten metal is dispersed in the form of particles due to centrifugal force upon contact with a spinning disc.

### Background of the Invention

**[0002]** Atomization is a process of breaking up a bulk liquid into small droplets. Any material existing in liquid state can be atomized into micrometer-sized particles. This technique is used to produce elemental metal powder or alloys.

**[0003]** Metal powder has a number of industrial applications, among which conventional powder metallurgy for the manufacture of parts by compaction and powder sintering, the formation of coatings by means of spray techniques, or the manufacture of components by means of additive manufacturing techniques stand out.

**[0004]** There are different atomization processes distinguished from one another by the techniques used for breaking up the fluid being used. These can be classified as:

- Atomization with fluids: metal in liquid state is transformed into small droplets due to the interaction of different high-pressure jets of water, gas, or oil, whether with a jet of water, air, hydrocarbons, or oil.
- Centrifugal atomization: molten metal is dispersed in the form of particles due to centrifugal force, such as spinning disc or rotating electrode atomization techniques.
- Other techniques, such as soluble gas, ultrasonic, or vibrating electrode atomization.

**[0005]** Centrifugal atomization using a spinning disc (Spinning Disc Atomization - SDA) is based on dropping a column of liquid against a disc, which can be flat or cup-shaped, among other shapes. When the liquid contacts the disc spinning at a high speed, the liquid spreads out over the surface of the disc due to the centrifugal force to which it is subjected. Then, when the metal reaches the edge of the disc, the surface tension is insufficient to maintain the bulk liquid mass and accordingly turns into a spray of small droplets which solidify and form a powder.

**[0006]** According to the speed, the radius of the disc, or the flow rate of the molten metal falling onto said disc, the liquid will be broken up into ligaments or sheets, or directly into droplets. Regardless of how the liquid is broken up, if the process is suitable, most of the particles end up being spherical.

**[0007]** By way of example, the spinning disc atomization (SDA) device comprises three basic groups:

- A crucible for melting the metal to be atomized, which must be adapted for pouring the metal onto the disc.
- A spinning disc, which is the element in charge of atomization of the liquid, and it must be capable of withstanding high speeds and temperatures.
- A chamber where atomization is performed which must be large enough to allow solidification of the particles before they hit against the walls of the chamber. It also preferably allows atomizing under conditions of inert atmosphere, and thus preventing possible oxidation of the particles as they solidify.

**[0008]** To assure the structural integrity of the atomizing disc, particularly where materials with a high melting point are to be atomized, a cooling system is needed for the atomizing disc, so that it can work at temperatures such that it maintains the suitable mechanical strength and toughness properties.

**[0009]** As an example, for AISI H13 steel, used in hot-working applications for cases where good mechanical properties at a high temperature must be assured, maximum temperatures recommended for working with these steels is about 450°C, since past this temperature their mechanical properties begin to deteriorate. This recommended working temperature is significantly lower than the melting temperatures of the metals, and for this reason the atomizing disc must be cooled.

**[0010]** For proper cooling of the spinning disc, said cooling today is normally provided through the lower portion of the atomizing disc. To that end, these designs mean that the rotating shaft is hollow, which leads to a complex design of the drive system of this disc, which is prone to misalignments and vibrations, with the subsequent problems this entails.

**[0011]** Therefore, an objective of the present invention is to provide an atomization device in which the rotating shaft of the motor is perfectly aligned with the spinning disc, thereby avoiding the use of mechanical transmission elements, such as gears, belts, or other elements such as elastic couplings for connecting shafts, which complicate the design and increase the number of rotating elements. The simplicity of the design minimizes vibrations in the atomizing disc.

### Description of the Invention

**[0012]** The atomization device of the invention solves the mentioned drawbacks and presents other advantages that will be described below.

**[0013]** The atomization device according to the present invention comprises a motor rotatably driving a spinning disc by means of a rotating shaft, and cooling means for cooling said spinning disc, wherein said cooling means comprise a cooling circuit extending around at least one portion of the rotating shaft and below at least one portion of said spinning disc.

**[0014]** Because the cooling circuit is not located in the actual rotating shaft, it is possible for the drive system of the disc to be simpler, enabling perfect alignment of the rotating shaft of the motor with the spinning disc. This minimizes rotating moving parts, which prevents vibrations from being produced.

**[0015]** According to a preferred embodiment, said cooling circuit is located in a stationary base in turn acting as a collector for the cooling circuit, comprising at least one inlet and one outlet for liquid coolant. These inlets and outlets for liquid coolant into the lower area of the disc are located around, on the sides, and parallel to the shaft of the atomizing disc. They are characterized by being able to be distributed in various positions and with various shapes and section around the area of the shaft of the disc.

**[0016]** Furthermore, the atomization device according to the present invention also advantageously comprises at least one gasket with its corresponding closure system should one be required, arranged between the spinning disc and the stationary base. Said gasket maintains tightness and confines the liquid coolant. This gasket can be made of graphite, for example. There is also arranged a sealing gasket between the shaft and the base.

**[0017]** Advantageously, said at least one gasket is arranged in a stationary manner, i.e., it does not spin with the spinning disc, as are the closure elements keeping the gasket in contact with the disc, such that only the shaft and disc part is rotating.

**[0018]** According to a preferred embodiment, said spinning disc and said rotating shaft consist of a single part, which also minimizes unwanted misalignments and vibrations in the assembly.

**[0019]** Preferably, the spinning disc is made of metal, with or without a refractory, anti-corrosion and/or anti-wear coating on its outer surface, although it can also be made of a ceramic material that adapts to the required mechanical conditions.

**[0020]** According to a preferred embodiment, the spinning disc has a diameter comprised between 20 and 200 mm and a thickness comprised between 1 and 15 mm.

## Brief Description of the Drawings

**[0021]** To better understand the foregoing, a set of drawings are attached in which a practical embodiment is schematically depicted merely by way of illustrative nonlimiting example.

Figure 1 is elevational cross-section view of the atomization device according to the present invention; and
Figure 2 is a plan view of the upper portion of the atomization device according to the present invention, with the spinning disc removed.

## Description of a Preferred Embodiment

**[0022]** As shown in the drawings, the atomization device according to the present invention comprises a motor 1 rotatably driving a spinning disc 2 through a rotating shaft 3. Said spinning disc 2 and said rotating shaft 3 may or may not consist of a single part.

**[0023]** As indicated above, atomization takes place by dropping a column or droplets of liquid against the spinning disc 2, which may be flat, cup-shaped, or have other shapes or geometries.

**[0024]** When the liquid contacts the disc 2 spinning at a high speed, said liquid spreads out over the surface of the disc 2 due to the centrifugal force to which it is subjected, and when the metal reaches the edge of the disc 2, the surface tension is insufficient to maintain the bulk liquid mass and accordingly turns into a spray of small droplets which solidify and form a powder.

**[0025]** Also as described above, this spinning disc 2 requires cooling which is provided, according to the present invention, by means of a cooling circuit, generally indicated by means of reference number 4, which is not arranged inside the rotating shaft 3, but rather extends around at least one portion of the rotating shaft 3 and below at least one portion of said spinning disc 2.

**[0026]** Furthermore, this cooling circuit 4 comprises at least one inlet 5 for liquid coolant, for example, water or oil, and at least one outlet 6 for said liquid coolant.

**[0027]** Said base 7 is stationary, i.e., it does not spin with the rotating shaft 3 and with the spinning disc 2. To that end, the atomization device according to the present invention comprises at least one, and preferably two, friction bearings 15 arranged between the rotating shaft 3 and the stationary base 7.

**[0028]** As can be seen in Figure 1, the cooling circuit 4 comprises at least one vertical inlet segment 10 and at least one vertical outlet segment 11 for the liquid coolant which are parallel to and spaced apart from the rotating shaft of the disc, which allows cooling specifically the upper portion of the rotating shaft 3 and the lower portion of the spinning disc 2.

**[0029]** To assure tightness, the atomization device according to the depicted embodiment comprises a sealing gasket 13, with its corresponding closure system should it be required, arranged between the stationary base 7 and the spinning disc 2, where said gasket 13 may preferably be made of graphite, though it could be made of any suitable material.

**[0030]** Said gasket 13, with its corresponding closure system should one be required, is stationary, arranged between the spinning disc 2 and the stationary base 7. Said gasket maintains tightness and confines the liquid coolant.

**[0031]** A sealing gasket 12 is also arranged between the rotating shaft 3 and the stationary base 7 for the purpose of confining the liquid coolant in the lower portion of the disc 2. This gasket 12 will preferably be made of an elastomeric material, though it may be made of any type of material that assures tightness in said area, such as graphite for example.

**[0032]** The spinning disc 2 can be made of any suitable material, but it is preferably made of metal or ceramic, with or without a refractory, anti-corrosion and/or anti-wear coating on its outer surface

**[0033]** Only by way of example, the spinning disc 2 may be made of AISI H13 steel, which is suitable for hot working. Furthermore, a suitable refractory coating could be made of alumina or zirconia to avoid interaction between the metal of the disc and the atomized metal.

**[0034]** For example, the diameter of the spinning disc 2 can range from 20 to 200 mm and the thickness can range from 1 to 15 mm.

**[0035]** The table below includes several atomization embodiments obtained by means of the atomization device according to the present invention:

| Material atomized | Speed of the spinning disc (rpm) | Mean particle diameter (μm) | Temperature of the molten metal (°C) |
|---|---|---|---|
| Tin | 30,000<br>40,000 | 90<br>75 | 400°C |
| Aluminum | 20,000<br>30,000 | 190<br>140 | 750°C |
| Copper | 15,000<br>20,000 | 180<br>150 | 1100°C |

**[0036]** Although reference has been made to a specific embodiment of the invention, it is evident to one skilled in the art that the described atomization device is susceptible to a number of variations and modifications, and that all the mentioned details can be replaced with other technically equivalent ones without departing from the scope of protection defined in the appended claims.

## Claims

1. Atomization device comprising a motor (1) rotatably driving a spinning disc (2) by means of a rotating shaft (3), and cooling means for cooling said spinning disc (2), **characterized in that** said cooling means comprise a cooling circuit (4) extending around at least one portion of the rotating shaft (3) and below at least one portion of said spinning disc (2).

2. Atomization device according to claim 1, wherein the cooling circuit (4) comprises at least one inlet (5) into the lower area of the spinning disc (2) and at least one outlet (6) for the liquid coolant.

3. Atomization device according to claim 2, wherein the at least one inlet (5) and the at least one outlet (6) for the liquid coolant are located around and to the sides of the rotating shaft (3) of the spinning disc (2).

4. Atomization device according to claim 1, also comprising at least one sealing gasket (13) arranged between a stationary base (7) and the spinning disc (2).

5. Atomization device according to claim 4, also comprising at least one sealing gasket (12) arranged between the stationary base (7) and the rotating shaft (3).

6. Atomization device according to claim 4 or 5, wherein said at least one sealing gasket (12, 13) is made of graphite or another sliding seal material.

7. Atomization device according to claim 4, 5, or 6, wherein said at least one sealing gasket (12, 13) is arranged in a stationary manner.

8. Atomization device according to claim 1, wherein said spinning disc (2) and said rotating shaft (3) consist of a single part or multiple parts.

9. Atomization device according to claim 1, wherein the spinning disc (2) is made of metal or ceramic.

10. Atomization device according to claim 1 or 9, wherein the spinning disc (2) comprises a refractory, anti-corrosive and/or anti-wear ceramic coating on its outer surface.

11. Atomization device according to claim 1, wherein the spinning disc (2) has a diameter comprised between 20 and 200 mm.

12. Atomization device according to claim 1, wherein the spinning disc (2) has a thickness comprised between 1 and 15 mm.

FIG. 1

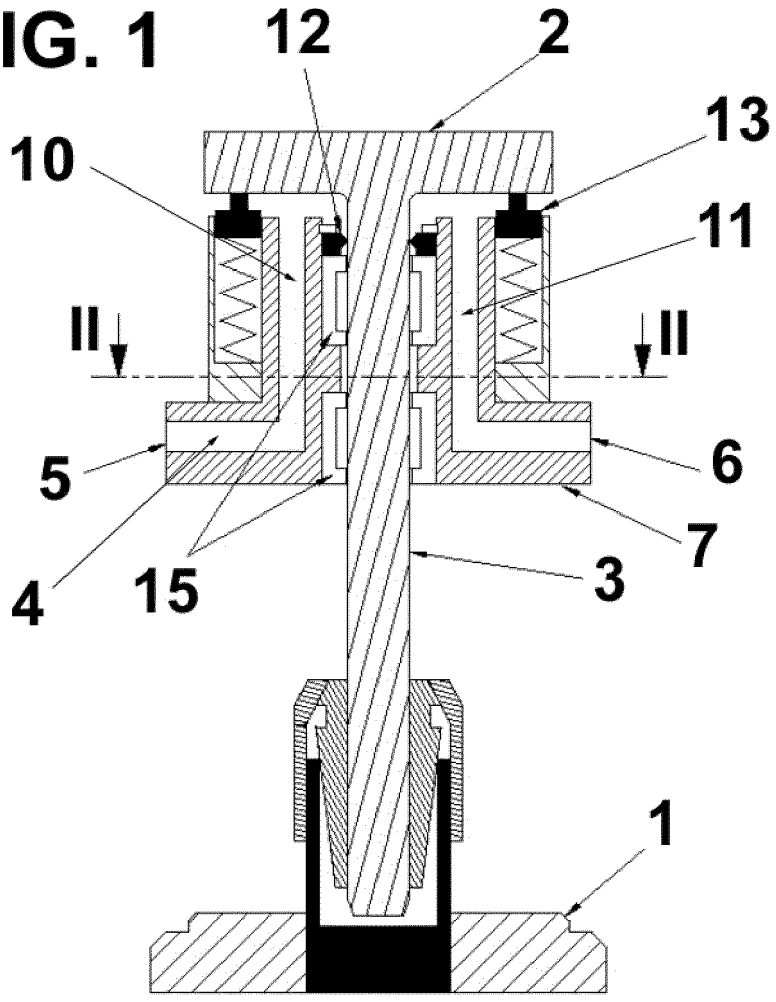
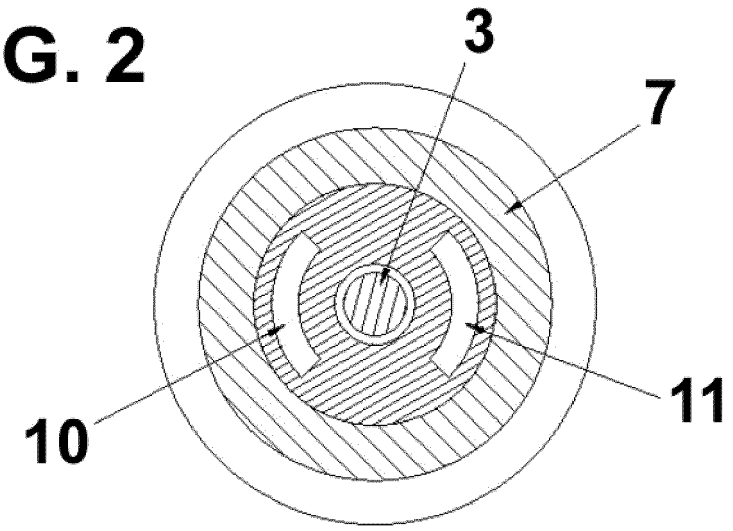



FIG. 2



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# EUROPEAN SEARCH REPORT

Application Number
EP 19 38 2517

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| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| X | WO 88/07979 A1 (BATTELLE DEVELOPMENT CORP [US]) 20 October 1988 (1988-10-20)<br>* page 1, lines 1-7 *<br>* page 5, line 20 - page 7, line 28 *<br>* page 10, lines 10-20 *<br>* figures 1-4 *<br>----- | 1-12 | INV.<br>B22F9/10 |
| X | OZTURK S ET AL: "EFFECT OF PRODUCTION PARAMETERS ON COOLING RATES OF AA2014 ALLOY POWDERS PRODUCED BY WATER JET COOLED, ROTATING DISC ATOMISATION", POWDER METALLURGY, MANEY PUBLISHING, LONDON, GB,<br>vol. 46, no. 4,<br>1 December 2003 (2003-12-01), pages 342-348, XP001244906,<br>ISSN: 0032-5899, DOI: 10.1179/003258903225008599<br>* page 343 - page 345 *<br>* figures 1,2 *<br>----- | 1-3,8-12 | |
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The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| The Hague | 31 October 2019 | Stocker, Christian |

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X : particularly relevant if taken alone
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## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 38 2517

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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31-10-2019

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82